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INVESTIGATION ON DIAMETER INCREMENT IN UNEVEN-AGED ORIENTAL BEECH FORESTS OF NORTHERN IRAN

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Introduction

Mixed and pure beech stands (*Fagus orientals* Lipsky) of the Caspian region covers 17.5 percent of surface and 30 percent of volume in northern forests of Iran. Group selection system has been introduced for application in these uneven-aged high forests (Sagheb-Talebi and Schuetz, 2002, Marvie Mohadjer, 2005). For application of this system, the frequency distribution (stem number and basal area) in diameter classes, annual diameter increment and stem number in the first diameter class (N_{10}) are the most important elements for achievement of equilibrium state in uneven-aged stands. It is also important to have information about ingrowth, outgrowth and removal rate (Schuetz, 1975 and 1997). According to the studies of De Licourt (1898) there is a decreasing coefficient for the stem number in diameter classes which depends on the species and density of the stand. Collete (1951) believes that achievement of this coefficient in uneven-aged sands is only possible by using of control method.

The aim of this study was to determine the diameter increment and N_{10} in oriental beech stands as a first step to provide data which is used to achieve the equilibrium state.

Materials and Methods

Six sample plots, each covering one ha (100*100 m) were selected by using of selective sampling method in natural oriental beech stands of northern Iran, Neka-Zalemroud region, Mazandaran province. The studied sample plots were located between 640 and 1540 m.a.s.l., with northwest direction and 15 to 20% of slope gradient. The crown canopy of the plots varied between 75 and 80%, stem number between 136 and 258 Nha^{-1}, basal area between 26 and 42.7 m^2ha^{-1} and volume between 388 and 509 m^3ha^{-1}. All standing trees with a diameter at breast height (dbh) more than 7.5 cm have been assessed in each plot. Moreover, marked and felling trees were recorded. Determining of diameter increment in the last ten years was done by using of increment borer in different diameter classes (al least three trees per diameter class). Data analysis was carried out by using of SPSS and Excel soft wares.

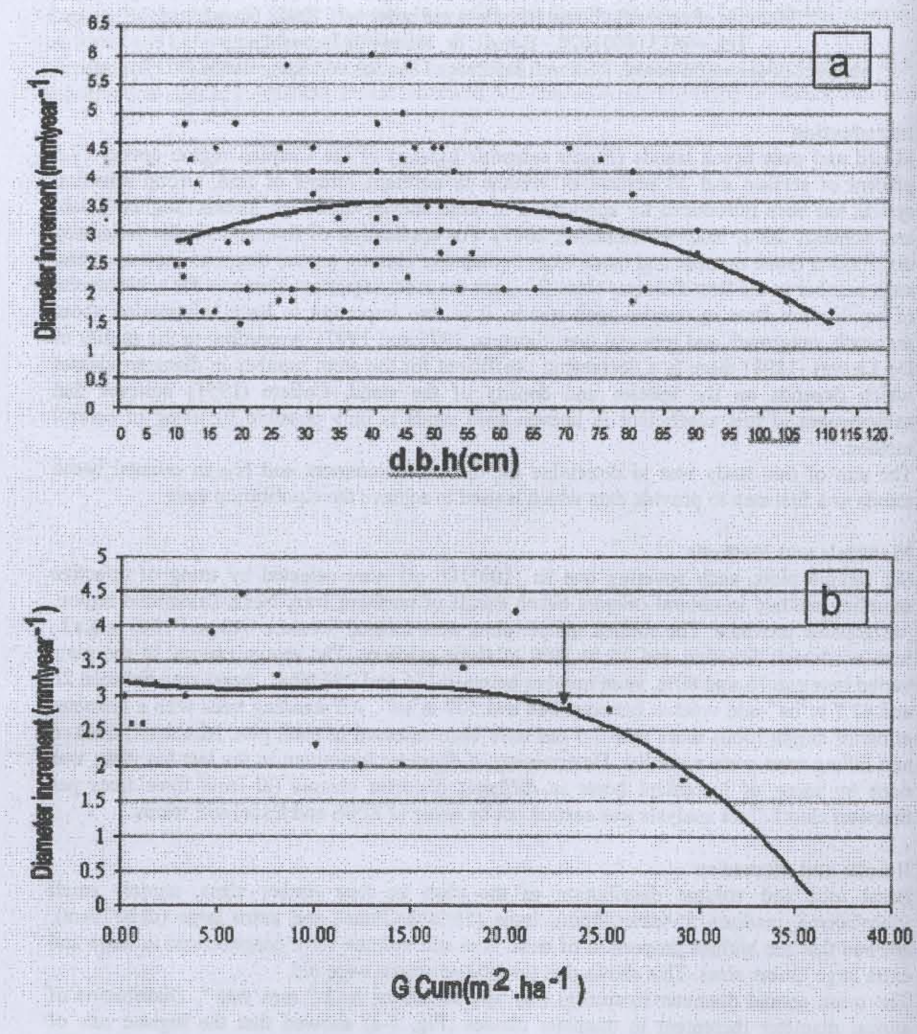
Results and discussion

Basal area and volume distribution of the plots in four timber sizes, namely small (dbh<30cm), medium 35<dbh<50cm), large (55<dbh<70cm) and extra large (dbh>70cm), showed that the highest proportion of basal area and volume were concentrated in large and extra large timber sizes. This shows that the studied stands were old.

The mean annual diameter increment (id) was calculated to 2.7 mm $year^{-1}$. Distribution of annual diameter increment in diameter classes (Fig. 1-a) showed that the highest rate of annual diameter increment (id=3.5 mm $year^{-1}$) could be observed between 40 and 55cm dbh classes.

Distribution of annual diameter increment in basal area classes (Fig. 1-b) showed that it starts with slightly more than 3 mm $year^{-1}$ in basal area of less than 5 m^2ha^{-1} and decreases to less than 0.5 mm $year^{-1}$ in basal area class of 35 m^2ha^{-1}. The mean annual diameter increment (2.7 mm $year^{-1}$) has been observed in 23 m^2ha^{-1}.

Figure 1: Distribution of annual diameter increment (id) in a) diameter classes and b) cumulative basal area.



Considering the growth rate and appearance of red rot and decay in wood, target diameter could be introduced between 80 and 85 cm in stands with 350 and 400 m^3ha^{-1} and a cumulative basal area between 20 and 25 m^2ha^{-1}. For improvement of the stand structure and becoming closer to equilibrium state, a stem number of 120 Nha^{-1} in the first diameter class (N_{10}) could be expected. However, at least two or three period of method control is suggested.

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MORPHOGENETIC RISK FACTORS OF FORKING ON YOUNG COMMON BEECH

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Fork on common Beech is a frequent flaw at the young stages of development which adversely affects the formation of a trunk. The morphogenetic determinism of forking remains still largely hypothetical. For instance, fork emergence is assumed to depend: (i) on the arrangement and dimensions of the buds at the end of the growth unit when the terminal bud is present (Bovlanski, Schädelin, Champagnat, Schütz, Sagheb-Talebi, Galoux, Kurth), and (ii) on the absence of this latter, generally due to late or early frost and browsing (Nicolini, Caraglio).

These two hypothesis were tested on young beeches (age < 20 years) in controlled conditions.

When the apical bud is present, we identified the length of the uppermost lateral buds relative to the length of the terminal one as the most explicative variable of fork incidence. In the case of apical bud death we analysed its consequences in relationship either with polycyclism or with late frost. We highlighted the influence of the polycyclism on the fate of the forks. Thanks to logistic regression we provided actual quantification of the effect of the identified variables and factors.

BEECH RECRUITMENT IN FOREST GAPS AFTER THE 1999 WINDSTORMS IN THE NORTH VOSGES. FROM DISPERSAL TO EARLY SURVIVAL

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Introduction

Natural disturbances have been shown to be crucial in forest dynamics. Tree recruitment for instance is highly dependent on the size of the gaps created by natural disturbance. Different processes such as seed production, seed dispersal, germination and seedling survival may be critical (Clark et al. 1998) may be of importance in tree recruitment as well. However, in forest regeneration, few studies have focused on seed supply and early stages of seedling recruitment (Jones and Sharitz 1998, Clark et al. 1999).

Therefore, the objective of the present study is to analyze the effect of different environmental factors on beech recruitment in gaps of various sizes ranging from 2.5 ares to 5 ha. We focused on three main processes: seed production and seed dispersal, seedling settling and seedling survival.

Materials and Methods

The experiment started in 2002 and was set up in the forest of La Petite-Pierre, North Vosges, France. In this forest, numerous gaps were created after the 1999 windstorm. 70 study plots were set up in 43 gaps, ranging from 2.5 ares to 5 ha, and 10 study plots under closed canopy. In each of those study plots, seed dispersal was studied in 2002 and 2003 by means of three seed traps (0.5 m²) and seedling recruitment by means of 12 permanent quadrats (of 8 m²). In 2003, beech seeds were classified in seeds with a fully developed embryo, in seeds predated before dispersion and in empty seeds. In each quadrat, beech seedlings were counted and their ages were determined for three consecutive years (2002, 2003 and 2004). In each study plot, soil characteristics (pH, C/N ratio and humus), topography and light environments were studied. Light environment was estimated by hemispherical photographs and by use of a calculated angle (called alpha). The measured topography was used to calculate the heat index (Geiger 1966).It corresponds to the average of the angles between the horizontal line and the top of the gap border trees in the east, south-east, south, south-west and west directions.

Seed dispersal and seedling recruitment were analysed thanks to the inverse modelling method (Ribbens et al. 1994). The number of seeds in each seed traps can be estimated by

[1] $$\hat{N}_i = \sum_{j=1}^{ntrees} P(diam_j) \cdot f(x_{ij}),$$

where $\hat{N}_i$ is the estimated number of seeds in the seed trap *i*, $P(diam_j)$ is the seed production of the tree with diameter $diam_j$ (j=1…*ntrees*), x_{ij}, the distance between tree *j* and seed trap *i* and *f(x)* a dispersal function. Three different functions were tested: the lognormal, the generalized exponential and the 2DT function. The best suited function was the generalized exponential function. The fitted parameters were determined using the maximisation of the likelihood function for a Poisson distribution.

Seedling number (at the plot level and at the permanent quadrat level) was estimated by:

[2] $$N_{seedlings} = T_{germination} \cdot \prod_{i=1}^{1} (1 - a_i \cdot F_i) \cdot N_{seeds}$$

where $N_{seedlings}$ is the estimated number of seedlings growing during the year of measure, $T_{germination}$ is the estimated germination rate, F_i the i environmental factors, N_{seeds} the estimated number of seeds. The fitted parameters ($T_{germination}$ and a_i) were determined by the Likelihood Ratio Test (LRT). This method takes into account both the quality of the fit and the complexity of the model (Johnson and Omland 2004).
Seedling survival was analysed by means of logistic regression and the best regression model was determined by means of the Akaike's Information criterion (AIC) (Johnson and Omland 2004).

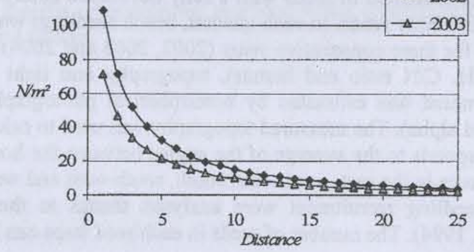
Results and Discussion

Seed production and seed dispersal

Estimated seed production differed both between years and with topography. Indeed estimated seed production was higher in 2002 than in 2003 and in 2003, compare to 2002, estimated seed production was larger for trees on slope facing north than those on slope facing south. As it is well known that seed production depends on the climate of a region, Therefore, it seems that the topography may modify the general influence of the climate at the stand scale.

The best model (maximum likelihood) was obtained by taking into account only trees within 25 m of each seed trap (Figure 1). Therefore, beech primary dispersal occurs at short distances but still at further distances than the tree crown size. Therefore, beech recruitment is compromised in the centre of gaps with a radius of more than 30 m due to a lack of seeds. This is particularly true when only the seeds with a fully developed embryo are taken into account as the estimated proportion of those seeds decrease from 65 % near the tree to 40.7 % at 25 m.

Figure 1: Number of seeds (N/m²) estimated by the generalized exponential function for a tree of 50 cm diameter, for years 2002 and 2003.



Seedling recruitment

Mean seedling recruitment rate was very low for the three years, corresponding to 0.29 % of the total number of seeds and 1.11 % of the full seeds. No significant difference was observed between plots in forest and plots in gaps.

Within gaps, the main factors affecting seedling recruitment were at the plot level: vegetation cover, heat index, soil disturbance and soil obstruction by branches, distance to the nearest beech tree, litter thickness and alpha angle. The seedling recruitment model (R^2=0.546, p<0.0001) can be expressed by:

$$N_{seedlings} = 0.0020 \cdot (1-0.58 \cdot veget) \cdot (1+0.82 \cdot Pert) \cdot (1-0.25 \cdot Enc) \cdot (1-0.38 \cdot HI) \cdot (1+0.59 \cdot D\min) \cdot (1+2.73 \cdot Ol - 2.45 \cdot Ol^2) \cdot (1+1.09 \cdot Alpha - 1.18 \cdot Alpha^2) \cdot N_{seeds}$$

The same factors were significant at the permanent quadrat level, except litter thickness and soil disturbance. The model (R^2=0.294, p<0.0001) can be expressed by:

$$N_{seedlings} = 0.0012 \cdot (1-0.74 \cdot veget) \cdot (1-0.85 \cdot Enc) \cdot (1-0.33 \cdot HI) \cdot (1+3.98 \cdot D\min) \cdot (1+1.29 \cdot Alpha - 0.69 \cdot Alpha^2) \cdot N_{seeds}$$

Where $N_{seedlings}$, is the estimate number of seedling and N_{seeds} the estimate number of seeds.

In our study, inverse modelling showed good results to apprehend seedling recruitment in a varied environment such as canopy gaps and enable to determine the predominant factors playing a role in seedling settling . Except for the soil obstruction by branches that physically prevent seedling recruitment, it appeared that the factors affecting seedling recruitment were those affecting the soil water balance. Recruitment limitation occurs with a decrease of water resources due to competition by herbaceous vegetation or by trees nearby. Topography influenced beech recruitment through its effect on direct sunshine that increased evapotranspiration and soil surface water content. Beech regeneration was difficult in gaps on slope facing south. Finally, it appeared that beech recruitment was better for alpha angles between 56 and 75°, corresponding to gaps of a few ares on a flat surface. As beech recruitment depends more on soil water content than on light level, there was a negative effect of direct sunshine on seedling recruitment.

Our study showed that in natural conditions and without vegetation, the control of beech recruitment is possible only the first 4 years after gap creation. After this period, the vegetation cover will prevent further seedling recruitment. This effect is very important in forests where *Rubus fruticosus* dominates the herbaceous layer.

Seedling survival

Seedling survival was greater in gaps than under forest canopy, especially for seedlings younger than two years old. The difference in seedling survival was highly significant (p<0.0001) for the seedlings of the year with 31.0 % survival under forest canopy and 71.0 % in gaps. Seedling survival increased with seedlings age. Survival was greater than 90 % for seedling older than two years and was similar between forest and gaps.

Seedling survival was affected by the different factors studied. However, the results obtained through logistic regression showed that other factors, such as biological factors, may be more important than abiotic factors. Our results showed that the effects of environmental factors affecting seedling survival were different between years: the general climate probably modify their effects.

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BEECH SILVICULTURE AND SILVICULTURAL TRENDS IN LORRAINE (NORTHEASTERN FRANCE).

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In Lorraine, European beech (*Fagus sylvatica*) trees grow in most forest areas from the limestone plateaus to the Vosges mountains. One-third of the production area (220,000 hectares) is covered by stands where beech is the main species. Beech constitutes an essential component in forest ecosystems in Lorraine.

A high production potential, but unknown risk ...

Lorraine belongs to the continental biogeographical region, the batico-rhenan sub-region. Plains, hills and plateaus (generally under 400 m a.s.l.) are mainly made of limestone, marl, clay, except the south part which stands on Trias sandstone formation. This is the beech-oak domain. The Lorraine side of the Vosges mountains (400 to 1300 m a.s.l.), which mainly consists of sandstone (lower Vosges) or crystalline (high Vosges) substrate, is the mixed conifer-beech domain.

Lorraine climate is semi-continental with oceanic influence. Its main features are :

- a high number of frost days (up to 90 days per year) ;
- a relatively short growing season : 7 months at most with an average yearly temperature of 9-10°C in plains ;
- high precipitation : from 700 to 2100 mm per year all along the year. According to the Gaussen's climate synthesis, there is no dry season. Yet, depending on the soil and water reserves, water may be deficient in spring.

These environmental and bioclimatic conditions are very favourable to beech and allow production of high value trees.

The trends presently observed in environmental factors must also be taken into account. Global change might be partly responsible for the increasing production of beech forests in Lorraine observed in the 20th century (Badeau *et al.* 1995, Bontemps *et al.* 2005), and for the higher frequency of windstorms and extreme droughts. The climatic conditions during the next century predicted by Météo-France models (Badeau *et al.*, 2005) suggest a reduction of the distribution area of beech in France.

A high diversity in structure and species ...

Historical and silvicultural considerations mainly account for the high diversity in structure and species observed in Lorraine beech stands.

- Old coppice with standards characterized by a low density of good quality stems. The coppice cut was stopped in the middle of 20th century. As a consequence, coppice has grown now inside standard crowns which induces mortality of low branches and a decreasing quality (mainly related wood colouring). Today, the aims in these mature stands are to manage threat to quality and to optimize the use of young stems for perpetuating forest covert. Now, the silvicultural regime consists mainly in uneven-aged management.
- Red-zone stands with many scrap metal woods due to both world wars. Extracting scrap metal wood by clear cutting was the aim in the last fifty years. That's generated many even-aged stand.

- Mountain beech stands, as many deciduous were cut for firewood, the number of coniferous tree increased in stands. Due to their strong natural dynamics beeches have remained in stands and are now forming mixed stands with coniferous trees. The silvicultural regime tends to preserve this mixing due to ecological and economical interests.
- beech stands totally (or partially) destroyed by windstorm in December 1999, where vigorous and very diversified seedlings are growing. Now, the aim is to manage these great surface of young stands more rationally by using the natural dynamic of vegetation.
- Even-aged stands , the main part of beech areas. Until 1990, this stands were manage with a long and high competitive period in young stands, followed by light thinnings from below. It resulted in pure pure and dense stands producing, in 120 or 140 years, very straight long timber. But sanitary problems often appeared with age (red heart, defoliations, bark beetles ...) and stringy wood (thin rings, thick wood) was produced, which did not sell well. That the reason why more dynamic silviculture has been developed, since 1990 in order to produce commercial stems in less than 120 years. This silvicultural regime consists on (expensive) precommercial thinnings in young stands, which produces more vigorous stems, but also many branches and a high forking risk. As a consequence, new itineraries, with some lightest (less expensive) interventions targeting at particular stem, have been proposed (see below).

Economical trends in the beech market

In the last decades, the following economic trends were noticed in many European countries (Wilhelm G.J., 2003 ; Gerkens and Gérard, 2004):

- low competitivity of beech wood in the industrial wood market;
- downward trend in sawn beech prices and highly fluctuacting market, especially for low quality wood;
- increasing labour cost.

In spite of uncertain economic prospects, with similar investments, high quality beech woods production allows higher and more stable economic value, compared to industrial wood production.

Silvicultural regimes traditionally applied on beech were based on a rotation of 120 to 140 years. In the last decade, research on the wood quality of beech trees have shown that a rapid growth associated with a short rotation produces the highest quality, characterized by large and homogeneous rings, a strait and cylindrical stem, and the absence of red-heart. Long rotations are also associated with many sanitary problems that affect old stands (more than 100-year-old) and strongly depreciate the stand value because of defoliation, bark beetles, general growth decline, and a much higher sensibility to windstorms (Bock *et al.*, 2003).

Foresters can also rely on progress in forestry research, better knowledge of ecosystems and species behaviour (autecology and synecology). Today, they know that investments are no longer necessary to sustain beech stands because of a favourable natural dynamic growth. But their high competitiveness must be controlled to preserve diversity.

Considering these ecological and economical uncertainties, forest managers wonder how beech trees will react and which place should be kept for beech in tomorrow's forests.

Beech silvicultural trends in Lorraine

Foresters don't know exactly how ecological and economical prospects will evolve in the next century and promoting highly diverse stands ensures a higher capability to adapt to these uncertainties. Mixed-species stands are known to have a higher resilience to extreme weather events or biotic threats, to have a higher stability of their economic value, and to fulfill many coming up social expectations such as landscape or environment management standards. Therefore, foresters are presently advised to :

- grow beech only on adequate sites,
- apply dynamic silviculture that allows rapid stem growth and short stand rotation,
- favour species mixture.

These general recommendations should induce vigorous stands able to withstand future stresses without growth reduction or other risks.

In this general context, beech silviculture in the public forests of Lorraine follows three main technical recommendations:

- Mix species at all stand stages;
- Reduce the investment by
  - focusing silvicultural treatments on a small number of high quality stems (beech or other high-value species);
  - using natural dynamics which are very favourable to qualify beech stems;
- Apply dynamic silvicultural methods and aim at short rotation period.

The general objective is to apply a dynamic and careful silviculture aiming at producing high quality white wood in clear and mixed stand. A series of silvicultural scenarii meeting this general objective were build, that allow to obtain various types of end-products and to adapt to different ecological and silvicultural conditions. These scenari are based on the natural dynamic of the trees and the stands, and can be parted into four successive phases: installation, qualification, active growth and maturation. Only the first two phases concerning early stand treatments will be presented here.

The installation phase covers the period from seed germination up to the first physical contact among the trees. The objective of this phase is to obtain a mixed-species regeneration which will allow a valuable output. The point is to further natural and diversified regeneration in a forest climate while controlling competing vegetation, at the lowest

Two itineraries are suggested:

- a rapid regeneration period, less than 15 years, to obtain vigorous seedlings and promote the survival and growth of light-demanding species;
- a long regeneration period, lasting approximately 30 years. This option is particularly interesting when the present mature stand is over capitalized, and allows to optimize the value of stand and to reduce economic loss.

The qualification phase covers the period from first physical contact among trees up to the acquisition of a trunk naturally pruned on a 5- to 8-m-height. The aim is to ensure that a potential for high quality stems is achieved in a short period of time. Three itineraries are suggested :

- a 'single tree itinerary' which gives priority to natural pruning and natural differentiation of 'super-vital' trees with some slight interventions (breaking or girdling of a few competing stems : it requires no more than 200 interventions per hectare during all the young stage ;
- a 'stand itinerary' with some 'traditional' interventions (extracting competing stem) but only targeted at precious wood species (approximately 50 to 100 stems per hectare), which offers more security for biodiversity ;
- a 'stand itinerary' with precommercial thinnings which stimulate diameter growth of 400 stems per hectare (especially precious wood species, but also beech stems).

The choice among the different itineraries is based on a technical stand analysis characterizing the site conditions and the potential of the present stand, and depends on the possible investment and the general management strategy of the owner. Presently, no management decision tool is available to forest practitioners to analyze technical and economical pertinence of the different possible silvicultural itineraries (especially 'single tree itinerary' or interventions targeting at particular stem).

Looking forward to hearing from the research community.

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NATURAL REGENERATION OF BEECH (*FAGUS SYLVATICA*) WITHOUT SOIL PREPARATION

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Introduction

In Sweden, as in most European countries, the common way to regenerate beech is to wait for a mast year, scarify, and cut a shelter after the seed-fall. Removal of the shelter-wood will be made in steps over a 20 years period (Bjerregaard and Carbonnier, 1979). The method is considered to produce good results, but there are some drawbacks:

- All sites are not suitable for scarification, for example sites with frequent boulders, steep slopes or wet soil. Furthermore sites with high biodiversity values, with historical remnants, and recreation areas should be treated with care.
- Much of the valuable timber is harvested during mast years witch has an adverse impact on the market.
- If the regeneration attempt ends with a failure, a second attempt will be difficult due to that sites often is invaded by grass and herbs.
- The uneven interval between mast years makes long-term planning difficult.
- The shelter-wood trees are often damaged by the sun or a rising water table.
- The possibilities to maximize the value of the old stand are limited since all trees do not reach their target diameters.

A more extensive regeneration method is practiced with good results at some estates in southern Sweden. Under a longer period seeds from several rich mast years, and also small amounts of seeds from less rich years, will contribute to form the next generation. No scarification is made, but the site conditions are controlled by several light cuttings, regulating the light conditions so the beech seedlings will be favoured in the competition against weeds. Similar methods are used in Denmark (Bornebuch, 1947) and northern France (Evans, 1982).

This extensive regeneration method has not the drawbacks as listed above. However the quality of the resulting regeneration has not yet been scientifically assessed. The main objectives of this study are to map the regeneration method and to study the regeneration dynamics. The objective is also to study the growth and yield of the shelter stand.

Materials and Methods

The study was started 1992 surveying seven beech stands on a bigger estate in south Sweden Site index varies from F 22 up to F 30, corresponding to from 4,3 up to 7,1 m^3 ha^{-1} and year (Table 1). At start the early regeneration-phase stands were in the beginning of, or just before, the regeneration phase, in the middle regeneration-phase stands about half of the regeneration time had passed, and in the late regeneration-phase about 75 % of the time had passed. In the two last stands the last shelter trees were cut in 2002 and 2000 respectively. In every stand four plots were randomly selected. At every plot the seed-fall was measured every year by three seed-traps. On each of the four plots, nine permanent subplots of 1 m^2 were established. On these plots both advanced and new seedlings and mortality among older generations were annually observed. Height was measured on a sample of marked seedlings of all cohorts. At every plot a sample of vegetation was gathered every third year. Diameter and height of shelter trees was measured on a circle with a radius of 25 m connected to each of the four plots. Silvicultural treatments have been decided and carried out by the local forester.

Table 1. Description of the seven stands of the regeneration study

Regeneration phase	Better site index, easy to regenerate	Medium site index, moderately difficult to regenerate	Poor site index, difficult to regenerate
Early	Stand 1	Stand 2	Stand 3
Middle	Stand 4		Stand 5
Late	Stand 6		Stand 7

Results and Discussion

For each of the seven stands the amount of seed were averaged over the mast years from 1992 up to the present (Table 2). In the period between the mast years only few seeds were collected in the seed-traps (500 seeds ha^{-1} in 1999, 1400 in 2001, 3300 in 2003 and 4800 in 2005). Interestingly there were mast years both in 1992 and 1993. It is also notable that during the 14 years observation period there has been 7 mast years, which is more frequent than is stated in most textbooks.

Table 2. Mast years and millions of seed ha^{-1} as an average for the seven stands in the experiment.

Year	Seed	Year	Seed	Year	Seed	Year	Seed	Year	Seed	Year	Seed	Year	Seed
1992	5,3	1993	1,5	1995	7,8	1998	0,9	2000	2,7	2002	5,7	2004	0,9

The total number of seedling show a big variation in the early regeneration-phase (Fig. 1), lower in the middle phase, and is almost none in the late regeneration-phase. Only the numbers of advanced seedlings (established before the observation period) are stable. In the beginning of the regeneration period and after cuttings in the shelter stands, the competition from other plants and shelter trees is small, and a greater number of plants are established after the mast years. This is most obvious when cuttings in the shelter-woods are carried out in connection to the mast years, e.g. in the second stand a cutting in the shelter-wood was made after the seed-fall 1998, resulting in almost 43 000 new seedlings ha^{-1} in autumn 1999. This mast year gave none, or relatively small, contribution to the number of seedlings in the other observed stands. After shelter-wood cuttings the amount of vegetation increase, more in the early regeneration-phase stands, where the competition from young beech is small. An abundant field vegetation will make it difficult for new seedlings to establish. A rapid decrease in the number of seedlings was observed the first years after the germination, especially in the early regeneration-phase stands. The advanced seedlings show however a low mortality during the whole generation phase. The reason is probably that they are well established and competitive. In the middle- and late regeneration-phase stands some of the advanced seedlings are cut in precommercial thinnings, since they owing to lack of competition has developed into wolf-types.

In almost all stands the advanced seedlings are the highest (Fig. 2). Only in two stands, where the number of plants, and the competition, has been low, plants of other cohorts have reached at least the same height. In the early regeneration-phase stands the mean height has not changed in two of the stands. In the middle- and late regeneration-phase, when the establishment of new seedlings is less frequent, the mean height increase. In the late regeneration-phase stands few new seedlings establish and because of competition their height growth is very low.

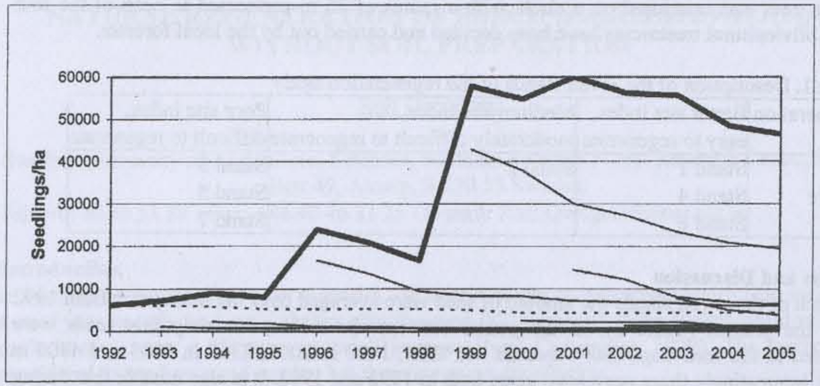

Figure 1. Change in number of seedlings in stand no 2, an early regeneration-phase stand of medium site index and moderately difficult to regenerate. Thick lines show the total number of seedlings, dotted line advanced seedlings, and thin lines the number of seedlings of every new cohort.

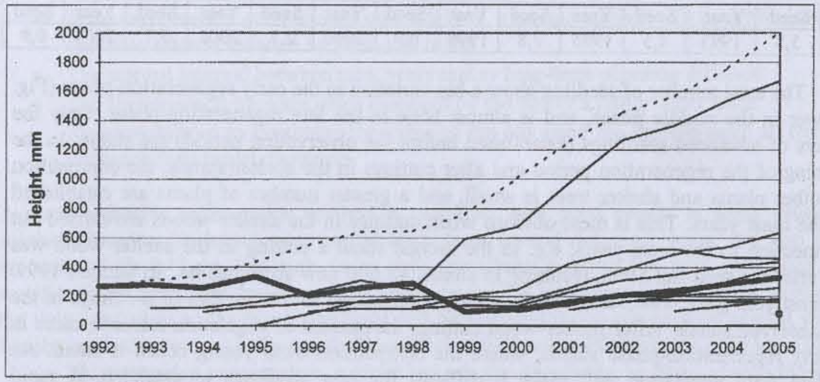

Figure 2. Height development in stand no 2, an early regeneration-phase stand of medium site index and moderately difficult to regenerate. Thick lines show the mean height, dotted line height of advanced seedlings, and thin lines the height development of every new cohort.

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ASPECTS ON EUROPEAN BEECH DECLINE IN SOME EXPERIMENTAL PLOTS IN ORIENTAL CARPATHIANS

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Introduction

The European beech have had some periods of weakness in Europe, noticed as: "*beech bark disease*" considered produced by *Cryptococcus fagisuga* and *Nectria coccinea*, but in many cases these biotic factors have been not recorded on high intensity and only the site and stand characteristics seem to be favouring the disease (Perrin, 1983; Lang, 1983; Lonsdale, 1983; Parker, 1983); "*beech canker*" produced by *Nectria dittisima* with high intensity in some special conditions (Perrin, 1981; Cael, N., 1999); and "*beech decline*" caused by a complex of biotic and abiotic factors (Nageleisen, 1993, 1994; Pilard-Landeau et al., 1994; Maresi et al., 1998) in which *Phytophthora* spp. may have a special role (Blaschke and Jung, 1998; Hartmann, 1998; Jung, 2004).

In Romania beech problems have been identified as "beech canker" (Marcu, 1978; Petrescu, 1971; Chiriţă, 1985 unpublished; Rang, 1992; Chira and Chira, 1998; Marcu et al., 2003), rarely as "beech bark disease" (Chira and Chira, 1998), and finally as "beech decline" (Chira, 2004). In all these cases the decline occurred after a combination of different factors: draught, frost, difficult site conditions, tree age, and several bark and wood fungi and insects (Chira, 2004).

The objective of this work has been to characterise the specific aspects of beech decline in some sites of Oriental Carpathians during the last period of time.

Materials and Methods

Beech decline has been studied in some experimental plots of the forest districts of Suceava (NE of Oriental Carpathians).

The evolution of beech decline and biotical factors (fungi, insects) has been surveyed in 11 experimental plots (min. 50 trees) between 2001 and 2005, but the decline symptoms, species resistance to decline, sanitary state of the trees etc. have been noticed on many other points. Soil influence has been recorded under declined and healthy points of the same parcel.

Results and Discussion

Decline symptoms. The following symptoms have been generally recorded: rare leafage, yellow leaf, and small leafs; shoot discoloration, branch dying (very frequent on thinner ones); infections with bark and wood fungi and insects; root discoloration; infestation with bark and wood insects; stem brown bleedings (generally linked by insects holes) and grey or blackish bark and red-brown wood discoloration; wet-hart on dying trees.

Climate conditions. Several dry seasons (with an extreme draught in 2000) seems to be the primary factor which starts beech the decline (Chira et al., 2004; Barbu, 2002-2004). Late frost of 1999 could also favour this process.

Stand characteristics. Stand composition has been highly variable, from pure beech forests to different mixed beech stands with sessile oak, common oak, hornbeam, common ash, Norway maple, sycamore, etc. Beech has had high productivity, ± even-aged structure, and normal density (0.7-0.8). Stand age has been old (109 yr. on average), with rare exception (42-57 yr.).

Site characteristics. Beech decline have been dispersed or grouped in relative small areas, rarely in large bands (strips). Beech decline has especially occurred in hilly zones, on relatively flat sites (plateau, low and long slopes, foot slopes, and narrow steps on slope), with very low external drainage. Rarely, beech decline has occurred on a slope, but only on lower physiological available volume of soil (sandy deposit). In all cases the control profiles have showed better pedo-hydric situation.

Associated fungi. *Nectria coccinea* and beech cankers have been noticed in a large number of beech stands, but no important correlation with decline has been calculated. *Schizophyllum commune* has frequently occurred on standing trees in some stands. The type of decline with bark and wood degradation has been rarely found. *Coriolus hirsutus* has generally followed *S. commune* on standing trees. *Armillaria gallica* have been seldom noticed on dead trees roots. Black-coloured roots have also been observed in the clayey horizons of soil.

Associated insects. In several cases the intensity of beech bark scale (*Cryptococcus fagisuga*) has been correlated with crown defoliation and tree diameter. Other bark insects (*Agrillus viridis*, etc.) have been recorded on many dying trees. From xylophagous insects, *Xyleborus saxeseni* and *Trypodendron domesticum* have been noticed, sometimes in relative high population.

Decline evolution. Both rapid and slow decline evolution have been noticed, but the second chronic phenomenon is more common (even it had a rapid start). In all the experimental plots the crown defoliation has decreased in time (2001-2005), even some moments of slow recovering followed some better seasons (2002, 2003 or 2005). In several years the mean defoliation increased from 29.8-42.2 % to 50.9-64.1 % (and rarely more).

In some points from the European Forest Survey (from Braşov county – SW of Oriental Carpathians) beech have shown a moment of weakness in 2000-2001, caused by late frost, summer draught and high infestation with *Phyllaphis fagi*, followed by a good recovery in 2-3 good years.

Other species resistance to decline. In some old plots (plateau on clayey soils) beech and silver fir have shown a similar high sensitive to decline; only some isolate trees of planted Norway spruce being moderate resistant. In some decline points, old (or even relative young) trees of sycamore maple and European hornbeam have shown a similar low resistance to decline. In the other cases, the (relative young) trees of European hornbeam have proved more resistant. In the majority of plots sessile and common oak have recorded a significant better resistance to stress than beech. In one case small-leaved linden has been more resistant to decline than beech, but in the past this species was disappearing on beech and sessile oak stands affected by canker / decline (Chira et al., 1998).

Management of beech decline. Sanitary cutting of the dying trees are indicated both to save the wood value and to prevent the infestation with fungi and insects. To re-evaluate the type of ecosystem in any decline forest, to understand if there is a concordance between the forest species requirements and the real ecological features of the forest site is considered fundamental. Therefore many of the studied forests have been reconsidered in this point of view.

Conclusion

European beech decline has been recorded between 2001 and 2005, especially in the hilly zone of north-eastern Romania. The phenomenon has start after a severe draught (and a late frost) and it has been favoured by other site (plateau or nearly flat slopes with soils excessively rich of clay or sandy slopes) and stand (old trees) factors. Associated bark and wood fungi and insects have been noticed. Sessile oak, common oak and sometimes hornbeam and small-leaved linden have been proved more resistant to the local conditions in the last decade climate stress conditions.

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BIOTIC FACTORS INVOLVED IN THE DECLINE OF BEECH IN ROMANIA

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Introduction

Beech had been considered for centuries a less valuable forest species of Romanian forests; due to this reason it has become a relevant species from the economic perspective relatively later compared to other forest species. As a consequence, natural beech forests have been maintained in many sites, often with high production potential and showing a special resistance to the action of biotic factors.

The beech is the most widespread forest species in Romania; it accounts for about 33% of the total forest area and it presently represents 50% of the total harvested wood volume. At the same time, it has an important silvicultural role in the beech-conifer mixtures, forming stable forests with Norway spruce. During the last three decades several species affecting the health of beech stands have been identified (phytopatogenous fungi, insects and even species of mites); this represents the beginning of the beech decline in Romania – less frequent and intensive that in other countries of Western Europe and North America.

Materials and methods

Observations and measurements in sample plots were performed. The analysis and measurement of the collected biological material (samples of branches with leaves) were consequently undertaken in the laboratory in order to establish the species which damage the beech.

Results and Discussions

The paper presents a summary of the results of the researches performed (and also published) in the last three decades on pests and diseases of beech leaf and bark; the most relevant species are presented in the table 1.

The data in the above table show that insect species (very different from the systematic point of view) prevail, complemented by „new" species - mites from Aceria genus.

Among the species identified on leaves, *Rhynchaenus fagi, Phyllaphis fagi, Dasychira pudibunda* and *Mikiola fagi* seem to be no longer under the natural biologic control; they produced for the first time gradations in our beech forests.

Moreover, after a natural cease of the gradation in the past, after a period of 7-10 years - the gradation periodicity, the species *Rhynchaenus fagi* appeared again in different forest areas of Romania; nowadays, it is recorded in almost all beech forests. Although a very small weevil, of only 2-3 mm length, it produces important damages, as it affects the leaves both in the adult and in the larva stage, and the attack cumulates during the growing season. *Typhlocyba douglasi, Apiognomonia errabunda, Aceria nervisequa* and *Aceria stenaspis* are species which have been identified for the first time on beech leaves in Romania.

Few species have been found on the bark of beech, only fungi from the Nectria genus and *Ascodichaena rugosa.*

Nectria ditissima – the beech cancer, is a species with a chronic evolution, which has lately extended to very large areas. The frequency of the attack is high in some forests, since the fungus can not be kept under control by removing the trees with cancer on the trunk during the tending operations.

Species which damage beech leaves and bark

Table no. 1

No.	Species	Class	Order	Family
	On leaves			
1	Rhynchaenus (=Orchestes) fagi L.	**INSECTA**	Coleoptera	Curculionidae
2	Phyllaphis fagi L.		Homoptera	Aphididae
3	Typhlocyba douglasi (Edw.) (=T. cruenta)			Jassidae
4	Dasychira pudibunda L.		Lepidoptera	Lymantriidae
5	Lithocolletis faginella Zll.			Lithocolletidae
6	Mikiola fagi Htg.		Diptera	Cecidomyiidae
7	Apiognomonia errabunda (Rob.) Höhn *f.c. Gloeosporium fagi* (Desm.et Rob.) Westend	**PYRENOMYCETES**	Sphaeriales	Diaporthaceae
8	Aceria nervisequa Nal.	**ARACHNIDA**	Acari	Eriophyidae
9	Aceria stenaspis Nal.			
	On bark			
10	Nectria ditissima Tul. *f.c. Cylindrocarpon willkommii* (Lind.) Wr.	**PYRENOMYCETES**	Sphaeriales	Hypocreaceae
11	Nectria coccinea (Pers.et Fries) Fries. *f.c. Cylindrocarpon candidum* (Link)Wolmer			
12	Ascodichaena rugosa Butin *f.c. Polymorphum rugosum* Hawksw. et Punith.	**DISCOMYCETES**	Phacidiales	Rhytismataceae

Regarding the fungus *Nectria coccinea*, found in our microflora, it must be carefully kept under control in order to observe a possible association with the louse *Cryptococcus fagisuga*, when it produces very serious damages – a necrosis of the beech bark.

We have not included in our investigations the xylophages species (especially the fungi that produce wood rots) as they are relatively well-known. We only emphasise that the beech is the most susceptible forest species from this point of view, the wood rot develops very quickly both in old and young trees, especially when they are stressed or dry, and especially in logs. The most common species involved in this process are *Fomes fomentarius, Schyzophyllum commune, Ganoderma applanatum, Stereum hirsutum, Coriolus hirsutum.*

In this category we also mention a „new" species, identified in Romania – *Inonotus nidus* – which produces a heart wood rot. The fungus is a debility parasite infecting wounds produced by improper pruning and frost cracks. It produces asexual spores (a rarely found phenomenon in basidiomicetes) and the basidiocarp is annual, lacking trama, with the feature of a crust which covers the trunk hollows.

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CONTRIBUTIONS TO THE BEECH ECOCLIMATOLOGY AND PHENOLOGY (1962–2006)

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Introduction

The beech (Fagus sylvatica) stands not only for a representative European species due to its spreading area but also for the main species of the Romanian forests; yet, in the past the beech was not paid enough attention. Only after an action initiated by ASAS and carried out in the Forest District Măneciu–Prahova in 1978, having as subject „the extension of resinous species outside the areal", following the protests of some participants who were defending the beech, a real campaign was launched in favour of this species: scientific meetings, articles published in the Forests Magazine, etc. But they didn't last long either. That is why we are greeting the Conference organized by the International Union of Forestry Research Organizations (IUFRO) in Brasov, with the theme **„Beech ecology and silviculture"**.

Materials and methods

The researches into the beech eco-climatology were performed by the author of the paper in the Curvature Carpathians (Brasov Mountains) throughout 45 years (1962–2006).

Most of the researches were performed in the mountainous massif Postăvarul (Brasov Mountains) at altitudes ranging from 534 to 1800 m.

The meteorological and phenological stations were installed under specific conditions at altitudes of 535 m, 609 m, 1026 m, 1450 m and 1724 m, so as to supply the field data characteristic to both phytoclimatic layers and areal limits – altitudinally – of the main forestry species in our country, including the beech. The meteorological measurements and the phenological field observations, as well as data processing have been carried out by means of common methods in climatology and phenology.

Results and discussions

The researches bring several contributions to observing the influence of climatic factors upon the natural, ecologic regeneration, upon the increases and upon the phenology of this valuable species of the Carpathian forests.

As far as the **natural regeneration is concerned**, the novelty aspects are firstly related to the influence of light, extreme temperatures, snow layer, late or early frosts.

It is well known that in our country the beech has the best climatic conditions in its habitat and it generally regenerates easily enough.

Yet, sometimes, during the seedling period, i.e the „ exchange of generations", the beech looses ground in competition with other species.

At this very moment both the beech mast sprung from November – December – January and the young sprung plantlets are not protected by the **snow layer**. It is the case of sunny slopes, hill tops and large peaks situated at altitudes lower than 1000 – 1200 m which often remain uncovered by snow and, when the **night frosts** occurs again, the sprung beech mast is completely damaged. Since it can not form the second root, the beech is defeated by the common oak or by other species that are not disadvantaged by such a „handicap", becoming „masters" on these types of grounds.

At mountainous altitudes, higher than 100 – 1200 m and even sub-mountainous (hilly), but on shadowed slopes, where the snow layer covers the ground until late in spring, the beech „fights" with the competitive species „on an equal footing", managing to grow in mixed forests in proportions that assure its continuity and even the achievement of pure beech forests of great productivity.

Therefore, **eliminating the beech from the sunny slopes is not an effect of the competition on the „light front" and of the „heat front", but a result of the temporary loss of the snow layer as an opportunity factor, with protective, decisive effect.**

In other words, **the relation snow layer – beech plantlets** represents **a key moment in the process of the beech natural regeneration, an important station-based factor of the prefiguration (accomplishment) of the natural bio geographic mosaic, of biodiversity.**

It is known that under other station and meteorology - based conditions as well as under brush conditions, the intense elimination of the beech plantlets and the significant diminution of the increases is caused by **the insufficiency of light, respectively by the shadows caused by the maternal brush**; this deficiency, specific to the vegetation period, is likely to equal and even to exceed the harmful effect of the above-mentioned meteorological factors. The comparative research into the dynamics of the amount of plantlets installed after the beech fructifications in 1968, 1973, 1978 followed by other researches developed in the experimental surfaces, „Crucea Albastră" – Poiana Braşov, „Warte", „Măgurele" – Cristian etc., as well as the biometric determinations on seedlings under different microclimatic conditions, conditioned by the different illumination (shadowing) degree as a consequence of variations in brush consistency, demonstrate, in a convincing manner, that beech silviculture asks for the consolidation of the new orientations (principles) of ecologic optics and attitudes, with important economic implications.

Named by the silviculture classics „the shadow species", the beech proved to be a species that, especially during the first years of vegetation, bears with difficulty shadowing the maternal brush; that is why the spring seedling may completely disappear until the end of the vegetation season or, through rare remained examples, to lead to very low increases and to disappear within the next years.

In the „in extenso" paper we are presenting multiple edifying data resulted from our researches as related to the influence of shadowing upon the beech seedlings. In this abstract we only mention the result of an experiment started in 1969: barely sprung plantlets in the spring of 1969, replanted on open ground reached, at 32 years old, 8 m height and 22 m diameter, while the seedlings that remained under the massif only reached 1,5 – 2 m height and around 1 cm diameter.

We also have other examples that prove that only exceptionally **the beech may be labelled as „shadow species" only if we wish to point out its exceptional capacity to beat the shadowing, its tolerance degree of the photic insufficiency. The beech's high demands related to light are indisputable.**

Consequently, we support the idea that in beech forests and exploitable beech mixtures it is necessary to reduce the regeneration period and the number of trees fellings, gathering the whole wooden material only by 2 tree fellings well coordinated with the fructification years.

Under the conditions of the phyto-climatic layering in the Curvature Carpathians, the beech is presented in all the layers and sub-layers, beginning with the hilly one, 200 – 300 m until the lower mountainous one (inclusively), respectively until the bases of pure spruce forests.

Following the topo-climatic researches carried out in Brasov Mountains throughout 1964 – 1996, upon relief forms and phyto-climatic layers, those values of the climatic parameters that define the altitudinal (local) limits of the beech habitat and of its divisions were determined. In the paper herein we are presenting the climatic characteristics of the slope's sectors which

offer optimal conditions for this species, so called „slope warm area", situated at altitudes ranging from 650 up to 1250 m and the climatic conditions from the altitude of 1450 to 1500 m, which represent the real barrier in the beech altitudinal spreading, as well as those from the depression plain of Bârsa, also not favourable for the beech.

The phenological observations on the beech, done from 1961 until now in Brasov Mountains led to important conclusions.

Against the background of the species' genetic program, the beech phenological rhythm is obviously conditioned by the evolution of meteorological conditions. For instance, as compared to the average date, April 17th, when the beech buds open (in Brasov at he altitude of 609 m), in different years, the same phenophase may register deviations of ± 20 days, i.e. 3 week accelerations or delays.

Altitudinally, the beech phenophases are late, on average, with 4 days/100 m level difference, which is confirmed by the fact that at the altitude of 1600 m, the leafing process begins only around June 1rst, and the end of the vegetation period, imposed by the emergence of early snows and frosts, takes place in the first half of September.

In the paper herein there are presented all the beech phenophases: the medium and extreme data when they were produced, at the altitudes of 600 m, 1000 m, 1450 m şi 1600 m, as well as the amount of adequate temperatures, the length of inter-phasic periods and the vegetation period.

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IS BEECH BY ANY MEANS AN INTERESTING SPECIES IN NORTH AMERICA AND HOW IS BEECH REGENERATED?

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Introduction

European beech (*Fagus sylvatica*) is a very important commercial species in Europe and the title of the conference highlights the fact that we are in Romania, the largest beech country. European beech is prized for its timber and many other uses, so it is easy to understand why European beech is interesting. However, European beech is only one of ten species of beech that are found worldwide.

American beech (*Fagus grandifolia*) is the only beech native to North America. This paper discusses two questions that are sometimes asked about this species: 1) is there any interest in American beech and 2) by what means does American beech regenerate?

Discussion

Description of American beech

American beech is a common tree species in the eastern forests of the United States. It is easily identified, even at a distance, because of its smooth, thin, light blue-gray bark, which can be seen on individuals of all ages. Other distinctive characteristics include long, narrow, sharp pointed, spindle shaped buds; deciduous simple leaves bearing parallel venation and short petioles; and a triangular edible nut contained in a bur that is 12-18 mm long. The leaves, buds, and bark of European beech are darker than its North American cousin. It is a slow growing but long-lived species that sometimes attains an age of 300 to 400 years. However, most trees of this age are usually affected by rot, particularly in the lower section of the stem. American beech trees reach heights of 37 m with a diameter of almost 1.2 m.

Range and Site

American beech is widespread in eastern North America extending from the maritime provinces of Canada south to the Gulf coast and west to east Texas. It occurs from sea level to 1,000 meters in the northern part of its range to 2,000 meters in the southern Appalachian Mountains. Typical sites within this area are moist, rich uplands, and lowlands.

Ecology

American beech is extremely tolerant of shade, prefers moist well-drained sites, produces root sprouts as well as stump sprouts, and is long lived. These characteristics place American beech as a long-term inhabitant in the forest types in which it occurs.

Beech is classed as very tolerant of shade and in some parts of its range it is the most tolerant species. Its principal competitors are sugar maple, eastern hemlock (*Tsuga canadensis* (L.) Carr.), and balsam fir (*Abies balsamea* (L.) Mill.). Beech prefers moist well-drained sites although it can survive on drier soils. It cannot endure prolonged flooding however. Beech sprouts well from the stumps of young trees but this trait diminishes as stump diameter increases. Beech trees may develop a large number of root sprouts or suckers. In some areas

this is the sole means of reproduction and there may be as many as 1700 to 2200 sprouts per hectare. This vigorous sprouting often interferes (moisture and shade) with the reproduction of other species. Beech is generally considered a slow grower and is long lived. Of 12 broad-leaved species rated according to their longevity, beech was exceeded only by white oak and sugar maple. Self pruning in beech is good in well-stocked stands but open-grown trees develop wide crowns with branches low to the ground. Epicormic branching is sometimes a problem in stands thinned too heavily.

Interest in Beech

American beech is a commercially valuable species because of a number of desirable properties of the wood. It ranks high in holding nails, but wood should be pre-bored prior to nailing because of the high density of the wood. The wood wears well and holds a polish, and it bends readily when steamed. Care is needed in gluing, but the wood finishes well with paint or transparent finishes. However, untreated wood is not durable and is subject to heartwood decay. Sapwood and heartwood are permeable when pressure-treated preservative compounds like creosote. But red heartwood is extremely resistant to penetration by preservatives by any means.

The wood of American beech has a number of uses: lumber, veneer, charcoal, railroad ties, pulpwood, cooperage, boxes, crates, baskets, pallets, furniture, flooring, sash, doors, trim, paneling, general millwork, woodenware, novelties, handles, brooms and brushes, food containers, turnery, and chemical extracts such as methanol, acetate and wood tar (creosote).

Thus there has been long-standing interest in American beech because of its commercial importance. But now there is interest American beech of a different kind that has resulted in changes to the composition of the forests containing beech and changes to the form of beech trees. This change has been brought about by the beech bark disease, which threatens the commercial importance of American beech.

Beech bark disease is an insect-fungus complex involving the beech scale insect (*Cryptococcus fagisuga*), the exotic canker fungus *Nectria coccinea var. faginataor* and the native *Nectria galligena* that kills or injures American beech. Beech scale was introduced to Nova Scotia around 1900 and the disease has subsequently slowly expanded its range through a large portion of the range of American beech (Morin et. al. 2003)

Mortality of beech is high in areas that are initially invaded. However, the disease does not completely eliminate the beech. Although the stem is killed, the roots are not and beech is capable of producing numerous sprouts from roots, which are capable of re-colonizing the site. The presence of this disease has raised questions about how to manage beech (Houston 2004).

Regeneration

Information about American beech regeneration has recently been reviewed by Nyland and et. al. 2006. Beech regenerates either by seeds or by root suckers. Seedling reproduction is more common in the northern part of the range while root sprouts are the dominant reproductive form in the south (Ward 1961). Although beech will sprout from stumps, coppice stands of beech are generally not common.

Regenerating beech and other hardwood species presents different challenges depending on whether beech bark disease has become part of the forest ecosystem or not. Mature beech killed by the disease produces a dense understory of young beech from numerous root sprouts. The understory is so thick and casts such a dense shade that other hardwood species are prevented from being regenerated. Unfortunately deer do not browse beech but prefer other tree species thus compounding the difficulty of regenerating other hardwood species.

Many hardwood stands have become less productive as a consequence of the activities of the beech bark disease. This loss of productivity is the result of a combination of the loss of large, mature, beech and the development of dense thickets of beech from root sprouts that inhibit the regeneration of less shade tolerant hardwood species. However, Leak (2006) recently reported that uneven-aged stands managed using single-tree selection over a 50 year period has improved disease resistance and increased the merchantable potential of stands treated in this manner.

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BEECH FORESTS IN JAPAN
- ECOLOGY AND SILVICULTURE -

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Introduction
There are 10 - 15 species in the genus *Fagus* in the world. Major distribution areas of *Fagus* species are temperate and humid regions in the mid-latitude of the northern hemisphere, which mostly overlap the populous areas of human being. Many of the beech species share common characteristics in ecology. At the same time, we may find a large variety of management systems among different areas of beech distribution, reflecting the differences in natural environment, human history, or social and economical situations of each region. In this paper, I provide an overview of ecology and managements of beech forests in Japan.

Distribution of *Fagus* in Japan
Two endemic species of *Fagus* are distributed in Japan, i.e. *Fagus crenata* Blume and *Fagus japonica* Maxim. Distribution and dominances are different between these two species. *Fagus crenata* is one of the most dominant species in cool temperate forests in Japan and ranges across almost allover the Japan archipelago, with the highest dominance in mountainous areas along the Japan Sea in the northern Japan (Fig.1). On the other hand, *Fagus japonica* is less dominant and its major distribution areas are restricted to the Pacific Ocean side of the main land Honshu (Fig.1).
In general, *Fagus crenata* has a single stem and tends to form pure stands, while *Fagus japonica* often forms multiple stems and grows in mixed stands with other broadleaved trees.
In forest ecology and silviculture, much more studies have been conducted for *Fagus crenata* than *Fagus japonica*, because of the greater dominance and commercial value of the former species.

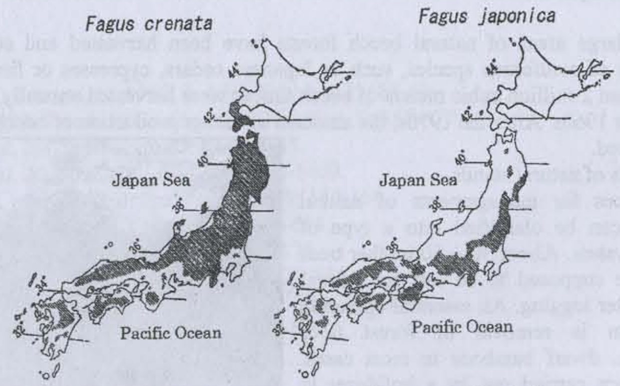

Fig.1: Distribution of two *Fagus* species in Japan

Association with dwarf bamboos

One of the distinguishable characteristics of *Fagus crenata* from European, Oriental and American beeches is association with dwarf bamboos (Fig.2). Most of the forest floors of *Fagus crenata* stands are densely covered with dwarf bamboos. Dwarf bamboos sometimes grow up to 3 m in height, and its above ground biomass reaches 8 kg m^{-2}.

Fig.2: *Fagus crenata* stand with dwarf bamboos in the forest floor.

Simultaneous deaths of dwarf bamboos, which occur once in several decades, is an important factor for natural regeneration of beech forests along with canopy gap formations (Nakashizuka et al. 1988).

Reproductive performances of *Fagus crenata*

Fagus crenata is a tree species showing the typical "masting" or "mast seeding" behavior, which is defined as an intermittent synchronous seed production within a population (Kelly 1994). In general, a good seed crop comes in every 5 – 7 years in a population of *Fagus crenata*.

Recent works have revealed that two annually-fluctuating factors are involved in the mast seeding of this species; 1) intensity of flower set, and 2) predation of immature seeds by insects (Yasaka et al. 2003). The most influential insects are three moth species of which larvae feed on immature fruits in early summer (Igarashi and Kamata 1997). Seeds damaged by insects are aborted, and the rates of predated seeds often exceed 90 % of total seeds. As the predation rate can be lowered in a year with abundant flowers following the year with little flowers, the large annual fluctuation in the number of female flowers is considered to have an evolutionary advantage for reproductive success by escaping potential predations by insects (Kon et al. 2005a).

The proximate factors causing annual fluctuation in flowering intensity of *Fagus crenata* are internal resource dynamics and weather cues, i.e. minimum temperature from late April to mid-May in the year preceding flowering (Kon et al. 2005b).

Silviculture of *Fagus crenata*

1. Brief history

In Japan, the large areas of natural beech forests have been harvested and converted to artificial stands of coniferous species, such as Japanese cedars, cypresses or firs, since the 1950s. More than 2 million cubic meters of beech timber were harvested annually at the peak years of the late 1960s. After the 1970s, the amounts of timber production of beech have been gradually reduced.

2. Managements of natural stands

Current practices for managements of natural beech forests can be classified into a type of shelter wood system. About 30 – 50 mother trees per hectare are supposed to be left for natural regeneration after logging. An essential operation in this system is removal of forest floor vegetations, i.e. dwarf bamboos in most cases. Scarifications are carried out by a bulldozer to remove dwarf bamboos (Fig.3). Root systems of

Fig.3: Scarification by a bulldozer for natural regeneration.

bamboo vegetations should be removed together with their above ground parts to suppress the recovery of vegetations. Herbicides are not used for vegetation control from the environmental reasons.

3. Afforestations

Afforestations of beech trees have not been so popular in Japan. Recently, however, quite a few attempts of afforestation are carried out for restoration of beech forests. Major causes of seedling mortality are damages by various mammals, such as mice, hares and deer. Another problem involved in beech afforestations is potential risk of genetic contaminations in natural populations of beech. Seedlings for afforestations are often brought from distant regions, because of shortages of seedling supply from regional seed sources. Some recent studies have revealed that the genetic variation showed strong geographic structure in natural populations of *Fagus crenata* (Tomaru et al. 1998). Thus, long-distant transportations of seedlings can result in genetic disturbances among natural populations.

4. Seed storage

For stable supply of seedlings from regional seed sources, a simple method for long-term storage of beech nuts were established to cover its relatively long intervals between good seed years (Koyama et al. 1997). Beech nuts which are dried to moisture contents below 10 % (dry weight basis) and stored at -20 °C can maintain their viabilities for at least 5 years.

Preservation of biodiversity in natural beech forests

One of the relevant topics related to beech forests in Japan is increasing public interests and expectations to conservations of biodiversity of beech forests. In 1993, the large area of pristine beech forests in the Shiragami Mountains in the northern most edge of the main land Honshu was designated as an UNESCO World Heritage site for its rich natural environment. Various large mammals inhabit in the region, such as black bears, Japanese serows, or snow monkeys which are the most northern-living non-human primate.

Impacts of climate changes

Some research projects on the potential impacts of global warming on the distribution and vulnerability of natural vegetations have initiated by a multidiscipline team incorporating the researchers from forestry and environmental sciences. Using the 1 km mesh data of climatic parameters derived from a climate change scenario, it was predicted that all beech forests in western Japan will be out of the suitable sites and that there will be more extensive areas suitable for beech forests over Hokkaido under warming climate in 2050 and 2090 (Matsui et al. 2004).

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PRE-COMMERCIAL THINNING OF BEECH: STRIKING THE BALANCE FOR TIMBER PRODUCTION, BIODIVERSITY AND FOREST RECREATION

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Abstract

Beech (*Fagus sylvatica* L.) is one of the economically most important tree species in Europe. It is often managed under silvicultural systems which include natural regeneration resulting in dense young stands. Many foresters consider pre-commercial thinning indispensable for the production of high quality timber and even for the maintenance of biodiversity and optimal opportunities for recreational activities.

This study comprises four contrasting management regimes for young beech, initiated at an age of 14 years: 1. no pre-commercial thinning, 2. stripwise thinning leaving alternate 1-1½ metre wide belts of beech, 2½. stripwise thinning followed by heavy selective thinning, and 3. perpendicular stripwise thinning leaving a 'chessboard' pattern of beech for subsequent selective thinning. In addition to these main treatments, the study includes effects of strip width, manual pruning, and stump height on tree and stand development.

Until an age of 21 years the height growth of potential crop trees was essentially unaffected by thinning practice, diameter growth was unaffected by treatment 2 but strongly promoted by treatment 2½ and 3, and natural pruning was hampered by increasing thinning grade. The exterior wood quality of potential crop trees (excluding natural pruning) improved with increasing thinning grade, except for the less optimal treatment 3. For ground flora, cover as well as species diversity increased with increasing thinning grade at this stage of stand development. Additionally, a vigorous understorey of beech and other tree species developed with increasing thinning grade due to stump regrowth and additional natural regeneration.

In conclusion, the study clearly indicates that the common practice of stripwise pre-commercial thinning is unjustified. The justification of heavy 'chessboard' thinning (with pruning) depends on whether the potential reduction in rotation length and the improvement in wood quality outweigh the discounted costs of pre-commercial thinning and selection and pruning of crop trees. Combined stripwise and early heavy thinning ranges between these extremes. However, biodiversity, forest recreation and other issues may override these conclusions.

EXPERIMENTS ON YOUNG BEECH STANDS SILVICULTURE AT THE FRENCH FOREST SERVICE (OFFICE NATIONAL DES FORÊTS)

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Introduction

In France, beech stands managed by the French Forest Service extend to large areas (745 000 ha). Due to low wood prices (since windstorms in 1999) and high cost of pre-commercial thinnings, silviculture of young beech stands appears now as a very important issue in high forests. The key question is: how to obtain stands of high quality at the end of the silviculture life cycle included a young stage (dominant height up to 14-17m) with minimum costs? High quality means 60 to 90 trees per hectare with sufficient natural pruning (6m to 9m of trunk without any living branch) and adequate vigor (dominant trees with large crown) guarantying high reactivity to dynamic thinnings at the adult stage. Nowadays, there is no consensus on the way to achieve such a goal. Clearly, pre-commercial thinnings trigger diameter growth but slow down natural pruning. This confusing trade-off lead to suggest two types of silvicultural scenarios: (i) one or two moderate pre-commercial thinning(s) (Ho = 4m, 8m) followed by a phase characterized by high density promoting natural pruning, (ii) no pre-commercial thinnings but extensive interventions favouring species mingling (see Bock, this meeting). This last scenario is rooted in the hypothesis of a natural social differentiation between trees during early development stages. Since 1987, the Research Department of the French Forest Service settled several experiments on young beech stands silviculture. Here, we quickly present these experiments and give some results on the trade-off between natural pruning and girth increment, focusing on plain forests.

Material and Methods

Two sets of experiments were used for this study.

- The first one encompasses 8 experiments (34 plots) dating from late 80's characterized by different modalities and different initial heights (Ho ≈ 7m-13m). The experimental designs consist on a set of several square or rectangular plots with just one factor tested (silvicultural treatment). Only one experiment have 3 replicates and two experiments concern plantations. These experiments contain control plots where very limited interventions were applied. On each plot, a sample of usually 250 selected trees per hectare was measured every 2, 3 or 4 years depending on the variable of interest: girth at breast height, height, height of the first living branch (among others).
- The second one consists in current multi-site experiments (5 sites[1], 30 plots of about 50 ares) dealing with stands of comparable initial height (Ho ≈ 3-5m). Two factors are tested (silvicultural strategy: 8 modalities; fertility: 3 modalities) and all sites have a control plot. The sample consists in 250 tree/ha representative of 500 selected trees per

[1] In fact, this network contains now 11 sites and more than 50 plots but just a part of it was used for this study.. This network will be extended in the next years.

hectare. Girth, height, height of the first living branch are also regularly measured in all plots.

We performed the same study than Duplat and Démarcq (2000, Oak-Key project). On each plot, we calculated the Reineke Density Index (RDI, see Reineke 1933: $RDI = N(d_g/a)^b$) based on the equation of LeGoff and Ottorini (1999) just after the first intervention (total number of trees and basal area are known on each plot through inventory). This allowed to calculate the relative Reineke Density Index, i.e. the ratio between the RDI in plots with interventions and the RDI in corresponding control plots:

[1] $$RDI_r = RDI_p/RDI_c$$

We also calculated mean girth increment (δC_p), mean height increment (δH_p), mean height increment of the first living branch (δHb_p) in each plot for 3 to 8 years after the first intervention, relative to the control:

[2] $$\delta C_r = \delta C_p/\delta C_c$$
$$\delta H_r = \delta H_p/\delta H_c$$
$$\delta Hb_r = \delta Hb_p/\delta Hb_c$$

We plotted each of these variable as a function of RDI_r and fitted non-linear mathematical models constraints by [1,1] using STATISTICA 6.0 software. Each model is given with its coefficient of determination R^2, proportion of the variation which is explained by the model.

In the analysis, we separated stands with initial height upper to 7m (first set of experiments: higher stands) from stands with initial height less than 7m (second set of experiments: lower stands). We also plotted curves obtained for sessile and pedonculate oaks (Duplat and Démarcq 2000).

Results and Discussion

Girth increment (fig. 1): for both lower and higher stands, the best model we found was an equilateral hyperbola (higher stands: R^2= 0,845; lower stands: R^2 = 0,766). Higher stands appeared to have higher response to interventions. With heavy interventions (RDI_r<0,2) a doubling or more of girth increment compared to control plot can be expected. Common oak species displayed the same qualitative response for lower stands. However, for higher stands Duplat and Démarcq found a linear response. As they didn't have stands with RDI_r lower than 0.2 we can not conclude on this difference.

Height increment (fig. 2): we found no significant relationship between δH_r and RDI_r for higher stands (Duplat and Démarcq found a significant one for oak species but with very low value of R^2). For lower stands (R^2=0,516), we can notice that only very heavy pre-commercial thinnings may significantly reduce height increment. There is no significant difference with common oak species.

Height increment of the first living branch (fig.3): the qualitative response of stands clearly depends on initial height. The best model we found was a logistic one for lower stands (R^2 = 0,791) and a equilateral hyperbola for higher stands (R^2 = 0,824). Such a qualitative response was also obtained for common oak species but in a different way. For lower stands, natural

pruning didn't slow down for weak interventions (RDI_r>0,6). Contrary to oak species, heavy interventions (RDI_r<0.2) in higher stands lead to a stop of the natural pruning process for common beech species.

These results confirm that interventions in young beech stands lead to an increase in girth increment and a decrease in height increment of the first living branch. There is no way to avoid such a trade-off for a single intervention on a period of 3 to 8 years. More studies must be conducted to conclude on a longer period. We hope this will be achieve soon with our current network of multi-site experiments on young beech stands silviculture.

Figure 1: relative girth increment δC_r as a function of relative Reineke Density Index RDI_r in higher stands (thick blue line) and lower stands (thick black line). Curves obtained by Duplat and Démarcq (2000) for common oak species are also drawn.

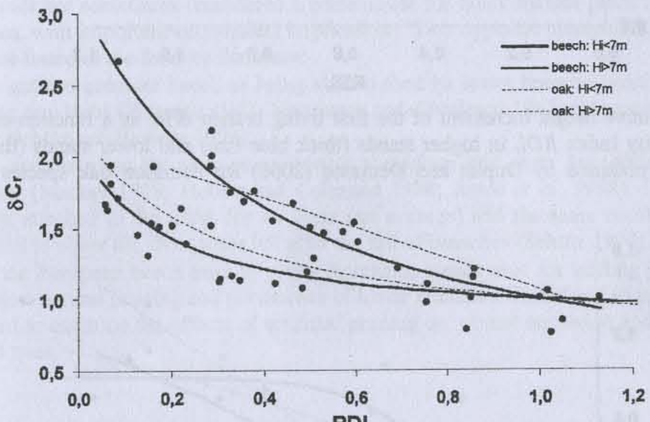


Figure 2: Relative height increment δH_r as a function of relative Reineke Density Index RDI_r in lower stands. The curve obtained by Duplat and Démarcq (2000) for common oak species is also drawn.

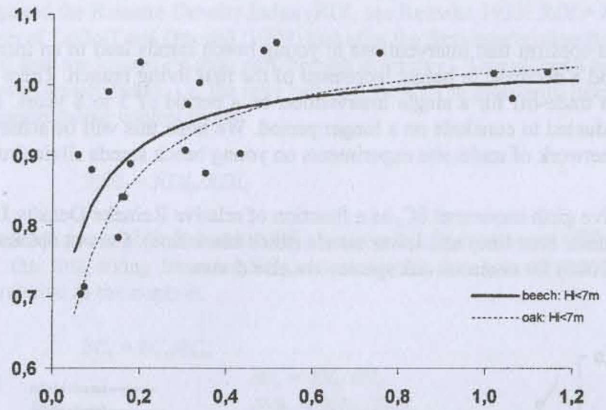
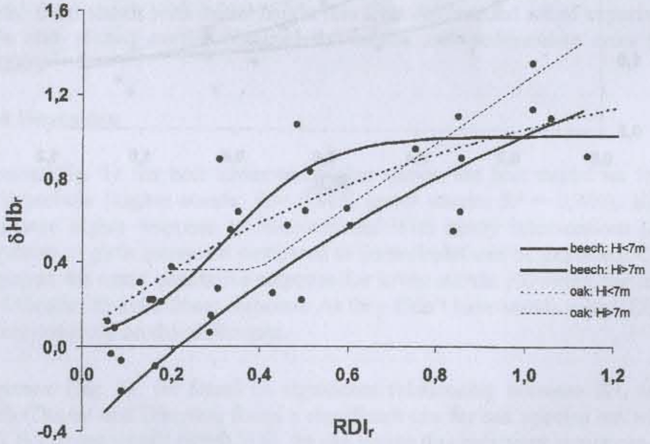


Figure 3: Relative height increment of the first living branch δHb_r as a function of relative Reineke Density Index RDI_r in higher stands (thick blue line) and lower stands (thick black line). Curves obtained by Duplat and Démarcq (2000) for common oak species are also drawn.



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EFFECTS OF EUROPEAN BEECH ARTIFICIAL PRUNING ON WOUND OCCLUSION AND WOOD QUALITY

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Introduction

European beech (*Fagus sylvatica* L.) has long been regarded as a forest species that prefers to grow in dense and closed canopy (Bagneris 1876). In naturally regenerated stands only few trees present adequate stem and crown form and high levels of stocking are required to provide a reasonable choice of *final crop trees* when thinnings commence (Evans 1984). Dense stands are sometimes considered a prerequisite for quick natural pruning of European beech trees, with important economical implications. Two opposite viewpoints regarding this process are found in the forestry literature:

- many authors consider beech as being able to shed its lower branches *easily* and without leaving any stubs (Petrescu 1963; Negulescu and Săvulescu 1965; Stănescu 1979; Schütz 1990; Schütz and Barnola 1996);
- other authors view the species as having a *medium* and even *low ability* for natural pruning (Mathey 1929; Hubert and Courraud 1998; Joyce *et al.* 1998). Dead branches remain attached to the trunk for 10 years (on average) and the same number of years is required to cover the short stubs left after the fall of branches (Schütz 1990).

Many of the European beech trees in young Romanian stands used for tending purposes show a rather slow natural pruning and persistence of lower branches. Therefore, an experiment was established to examine the effects of artificial pruning on wound occlusion and wood quality of pruned trees.

Materials and Methods

In May 2001 a cleaning-respacing experiment was carried out in a 15-year old, pure and even-aged European beech stand (sub-compartment 99A, Management Unit III Budila, Teliu Forest District, Brasov County, Romania). Two experimental blocks were established:

- block I with four plots of 25 sq.m. each (5 x 5 m);
- block II with four plots of 100 sq.m. each (10 x 10 m). In both blocks, plot 4 was kept as control whereas cleaning-respacing interventions of different intensities were performed in plots 1, 2, and 3.

In addition to removal of undesired trees (e.g. low quality, forked, with cankers, wounds, too dense, etc.) in plots 1-3 of each block, a certain number of the trees left (73 individuals, of which 18 in block I and 55 in block II) were pruned with pruning saws. 29 branches were pruned in block I and 71 branches in block II.

The basic data collected from these 73 trees and 100 branches in 2001 included:

- diameter at breast height (d.b.h.);
- location of each branch removed (height from the ground level);
- bole diameter at branch height;
- 2 axes (vertical and horizontal) of all wounds produced by pruning.

In April 2006 all these trees and wounds were re-measured for: (a) d.b.h., (b) bole diameter at pruned branch height, (c) horizontal and vertical axes of all pruned branches. In addition, 5 trees (with 5 wounds) in block I and 7 trees (with 9 wounds) in block II were cut down at ground level.

Results and Discussion

a. Geometrical form of pruned branches

The length of vertical axis (Va) ranged between 1.4 cm and 8.9 cm while the length of horizontal axis (Ha) ranged between 1.1 cm and 6.5 cm. 81 per cent of pruned branches had Ha shorter than 3.0 cm and only 3 per cent of them were longer than 5.0 cm.

In terms of Va:Ha ratio 93 out of the 100 pruned branches were of ***elliptical*** form, with Va:Ha higher than 1, and the other 7 pruned branches were of *circular* form (Va:Ha = 1).

b. Closure of pruned branches

Four years after pruning 73 per cent of wounds were perfectly (fully) occluded (Table 1).

Table 1: Partially and fully occluded pruned branches

Pruned branches with horizontal axis of……cm (no.)												Total (no.)	
1.1-2.0		2.1-3.0		3.1-4.0		4.1-5.0		5.1-6.0		6.1-7.0			
POa	FOb	PO	FO	PO	FO	PO	FO	PO	FO	PO	FO	PO	FO
8	*34*	12	*27*	2	*8*	2	*4*	2	-	1	-	27	*73*

Note: POa = partially occluded; FOb = fully occluded

The majority (74 per cent) of partially occluded wounds has reduced their area with at least 50 per cent. Wounds with Ha of maximum 3 cm accounted for 74 % of wounds still open. Such wounds were located especially on low diameter (mostly less than 4 cm) trees, less vigorous (Kraft classes III-IV) and slow growing trees (with d.b.h. increments as well as radial increments at wound heights close to 0 cm).

All three wounds with Ha longer than 5 cm were still non-healed over, reducing their area between 28 and 97 per cent. These wounds, as well as the majority of still open wounds with horizontal axes longer than 3 cm, are located at lower heights from ground level (less than 80 cm).

c. Wood quality in pruned trees

Wood colouration is mostly confined to the inner part (up to the central stem core) of branches removed during pruning for both perfectly occluded and still open wounds. Only in very few cases brown traces developing downwards the wound were detected, with a length of maximum 10 cm. In all cases no traces were detected upwards the wound.

The growth rings that developed after pruning were perfectly healthy in both fully and partially occluded wounds, without any form of colouration or rot.

Our findings are in agreement with results from previous similar studies in Europe (e.g. Soutrenon 1990, 1991, 1993, 1996). This experiment suggests that the Shigo's theory of compartmentalization (Shigo and Marx 1977) may also apply to European beech trees subjected to artificial pruning.

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